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Tumors of the Chest Wall

Paul Stelzer, M.D. and William A. Gay, Jr., M.D.†*

Tumors involving the modified sweat glands on the anterior chest wall of females constitute, by far, the most common chest wall tumors. It is not within the scope of this article to consider these tumors or those arising either from the mesothelial cells on the inner lining of the chest wall or from the ganglia or nerve roots in the posterior mediastinum. Instead, it is our intent to focus upon the evaluation and surgical treatment of patients with primary tumors arising largely from the supporting structures of the chest wall.

GENERAL INFORMATION

Primary tumors of the chest wall are quite uncommon. Of 2,000 primary bone tumors in the series at the Mayo Clinic reported by Pascuzzi and associates in 1957,[28] only 126 (6 per cent) occurred in the ribs and 18 (1 per cent) were in the sternum. Nearly half of all chest wall tumors originate in cartilaginous tissue,[30] but it is interesting that in their report of such tumors in 1951, O'Neal and Ackerman[26] could locate only 85 instances in the previously published literature and could add only 11 cases of their own.

Metastatic malignancy must always be considered when a patient presents with a chest wall tumor, particularly if there are multiple sites of involvement noted. Malignancies of breast and lung can involve the chest wall by direct extension as well as by the metastatic route. Other tumors likely to metastasize to ribs and sternum include those arising in the kidney and prostate. Renal and thyroid malignant tumors in the sternum may even mimic aortic aneurysm by presenting as a pulsatile mass.[23] As far as solitary lesions of the chest wall are concerned, *metastatic lesions occur with about the same frequency as do primary tumors.*

Although *primary chest wall tumors* are in themselves rare, *more than half are malignant,*[12] and these are particularly lethal. Perhaps one reason for this is the unusually long delay time, averaging six months, between onset of symptoms and radiographic detection.[6] Threlkel and

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Adkins,[31] reporting the 30-year Vanderbilt University experience in 1971, cited an 18 per cent 10-year survival among their 23 patients, and three of the four living patients had residual disease at the time of the report. In another long-term follow-up of patients with primary malignant tumors of the chest wall[33] the great majority of deaths were "disease related." Early recognition and prompt treatment of these highly lethal tumors is, therefore, of paramount importance.

CLINICAL FEATURES

Pain and the presence of a mass have been the two most common complaints of patients with chest wall tumors, and many patients experience both. Although localized persistent pain of the chest wall is a very common complaint in patients found to have malignant tumors, this complaint is also present in up to one third of those having benign tumors.[26] Oftentimes patients notice a lump many months before it is brought to the attention of their physician. Local trauma may have focused the patient's attention on a mass, but it is doubtful that this trauma plays any significant role in its development, except perhaps in fibrous dysplasia.[6, 25] Knowing the location of the pain or mass is sometimes helpful, since, for example, the majority of tumors of cartilaginous origin occur along the costochondral junctions,[21, 26] whereas fibrous dysplasia tends to occur over the posterior chest wall.[26] Tumors of the sternum are almost always malignant and should be assumed so until proved otherwise.[23]

Although there is a tendency for malignant tumors to occur in older patients, age per se is of little prognostic significance. Ewing's sarcoma is more likely to occur in the adolescent age group and myeloma is more common in persons over 50, but primary chest wall tumors can, and do, occur in all age groups. Tumors of the chest wall, both benign and malignant, are twice as frequent in male patients as in female patients.

If a mass is present, its characteristics should be carefully noted. In addition to location, texture, tenderness, and mobility may give clues to the nature of the lesion. Fixation to or involvement of the overlying skin may be evident. Size is a key element in determining the likelihood of malignancy, with those tumors exceding 4 cm in diameter proving consistantly malignant in the series reported from Memorial Hospital for Cancer in New York.[22] The presence of fever or adenopathy may suggest a myeloproliferative disease.

Laboratory examinations are usually of little help, with certain specific exceptions; for example, the erythrocyte sedimentation rate (ESR) may be elevated in instances of Ewing's sarcoma.[13] The differential white blood cell count may also give evidence that points toward a disseminated myeloproliferative disorder. The serum alkaline phosphatase level may be elevated in metastatic tumors to the bony structures. Elevation of acid phosphatase levels in instances of metastatic involvement of the bony structures suggests a prostatic primary. Electrophoresis of serum proteins may, in some instances, uncover proteins

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specific for myeloma, but the Bence-Jones protein was not present in any of 15 myelomas of the rib reported in the Mayo Clinic series.[28]

Radiographic evaluation of the chest wall is most helpful in defining the scope of diagnostic possibilities and the extent of disease. A local abnormality is almost always visable, even in the soft tissue neoplasms of the chest wall. Posteroanterior and lateral roentgenograms of the chest are routinely obtained, but oblique views of the ribs and sternum will frequently be necessary to better define the lesion. Tomography, both standard and computerized, is available for finer delineation of the tumor and the extent of its local involvement.[18] Angiography may be useful in special circumstances.[23] Sharp delineation and intact cortical margins as seen on the roentgenograms are characteristic of benign tumors, whereas malignant tumors are usually poorly defined and cortical disruption is common. Occasionally, old rib fractures, calcified prominent costal cartilages, myositis ossificans, prominent or bifid xyphoid, and osteomyelitis of bony structures in the chest can give misleading pictures that may suggest tumor.

Accurate histologic diagnosis is essential to the treatment of chest wall tumors. In general, needle biopsy is not recommended unless there is a strong suspicion of myeloma or metastatic disease.[23] Small tumors (those less than 2 cm in diameter) should be excised, a procedure that, in most cases, will be curative. For larger tumors, however, a *carefully planned open biopsy* must be undertaken to obtain adequate tissue and should be performed in such a way as to not compromise the incision for a future definitive resection.[22] The treatment of choice for most tumors of the chest wall is surgical excision. The myeloproliferative group of tumors provide an exception to this, since in the treatment of these lesions radiotherapy plays a more prominent role.[22, 25, 33]

BENIGN TUMORS

Chondroma

Slightly less than half of all primary chest wall tumors are benign, and the vast majority of these are of cartilaginous origin. These tumors are typically located at the costochondral junctions and occur most often in patients in the second and third decades of life. This tumor usually presents as a painless mass on the anterior chest wall. Chest roentgenography reveals a medullary mass that may thin the overlying cortex but does not penetrate it,[13] and there may be stippled calcification in many instances.[26]

Although chondromas may occur in any site in the body where cartilage is found, the ribs (Fig. 1) are the most common site, with up to 31 per cent of tumors being found there.[30] Left untreated, these tumors can grow to a very large size, sometimes exceeding the 4 cm limit of benignity. One report[27] discusses four patients whose superstition kept them from surgical excision for up to 30 years. One of these patients had a tumor that weighed 11.25 kg.

Although a mass is often palpable in these patients, the skin and

Figure 1. This x-ray film shows a chondroma of the rib.

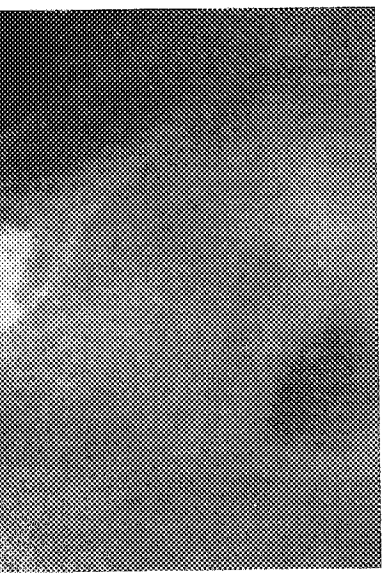
muscle tissue overlying the tumor is nearly always freely movable, and, except when there has been excessive palpation or trauma to the area, it is rarely tender. Excision of the involved costal cartilage along with a short segment of the accompanying rib is curative.

Fibrous Dysplasia

Equal in incidence with chondroma,[3] fibrous dysplasia represents up to 20 or 30 per cent of all tumors of the chest wall. This tumor presents as a painless, slow growing mass usually located in the posterior rib area (Fig. 2) and occurring in younger patients. Its growth usually ceases at puberty. A history of trauma can sometimes, but not always, be elicited.[6, 25] Depending on its location, the mass can usually be palpated through the skin, which is freely mobile over it. X-ray films reveal a thin expanded cortex lying over a fusiform osteolytic lesion in which trabeculation may be visable.[13, 26] The recommended mode of treatment is excision of the involved rib segment with a reasonable margin on either end. This is usually curative.

Osteochondroma

Osteochondroma is a small, hard, painless tumor occurring rarely but usually found in young patients. In the rib it appears as an excrescence of cartilage with a calcified cap projecting out of the rib itself (Fig. 3). Growth of the tumor is usually arrested at the time of closure of the nearest bony epiphysis. If later growth occurs, especially if it is accompanied by pain, questions of malignant degeneration should arise. Malignant degeneration is quite rare when the lesions are solitary but may be as high as 20 per cent in the hereditary form of multiple exo-



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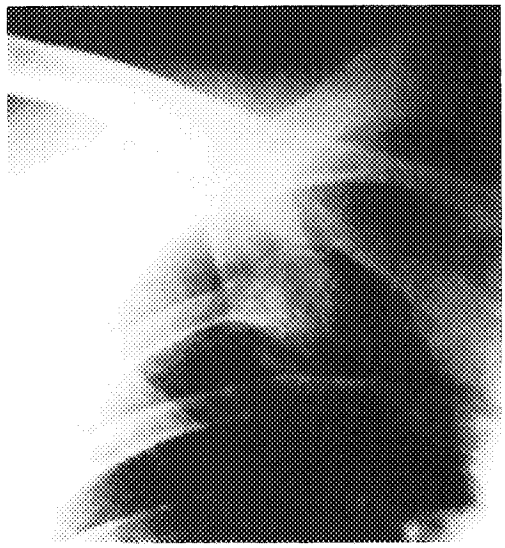

Figure 2. Fibrous dysplasia of the third rib is shown in this x-ray film.

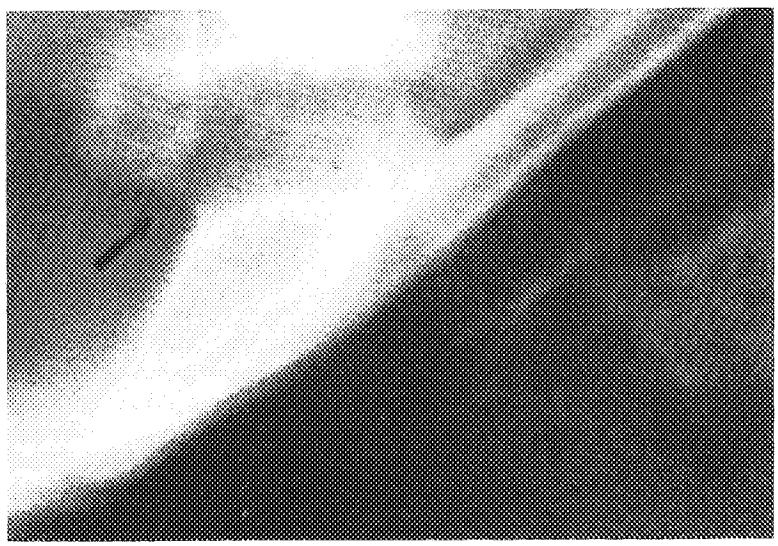

Figure 3. This x-ray film reveals an osteochondroma of the first rib.

stoses.[26] Surgical excision is usually adequate if the lesion is excised flush with the plane of the rib, but care should be exercised to guarantee that the cartilaginous growth center is present in the resected specimen. If there is any doubt, a segment of rib should be excised. Surgical excision usually results in cure.

Neurogenic Tumors

Neurogenic tumors may arise from the intercostal nerves, which lie in close association with the inferior margin of each rib. These tumors may cause pain in the distribution of the affected nerve. A mass may be palpable between the ribs, but, more often, special radiographic techniques will be necessary to adequately visualize the tumor. Two types of neurogenic tumors have been described in this area. The gray, unencapsulated neurofibroma is the more common of the two and may occur either singly or be associated with multiple neurofibromata in von Recklinghausen's disease. The other type of tumor is the yellow, encapsulated neurolemmoma (schwannoma), which is usually solitary. Since malignant change may occur in as many as 15 to 20 per cent of these tumors, generous surgical resection is advised for both relief of symptoms and establishment of a positive diagnosis.[15]

Desmoid Tumors

Desmoid tumors of the chest wall are quite rare and, although benign, exhibit aggressive local fibrosis of the surrounding tissues. Their rareness is brought out by the fact that only 26 patients with this lesion had been seen in the course of 62 years in the Mayo Clinic series.[8] Pathologically, the firm, dense, white tumor consists of reticular bands of interlacing tissue on its cut surface, and, microscopically, mature collagen is seen, presumably coming from the well-differentiated fibroblasts.[8]

Unlike other tumors of the chest wall, desmoids are twice as common in women as in men. The intercostal musculature seems to be the preferred site of origin for these tumors. Not infrequently the tumors will arise in areas of previous trauma or surgical incisions. The locally invasive nature of this otherwise benign tumor makes complete resection difficult. Reexcision is indicated whenever recurrence is documented.[8]

MALIGNANT TUMORS

Chondrosarcoma

Chondrosarcoma is the most common of the primary malignant tumors of the chest wall. As with its benign counterpart (chondroma), the most common location is at the costochondral junction; however, the tumor may occur anywhere along the course of the ribs. Chondrosarcoma is also the most common malignant tumor occurring in the sternum (Fig. 4). The tumor generally exceeds 4 cm in size at the time of its discovery and may become quite large. Prior to the 1943 report of Jaffe and Lichtenstein[17] there was considerable controversy regarding the his-

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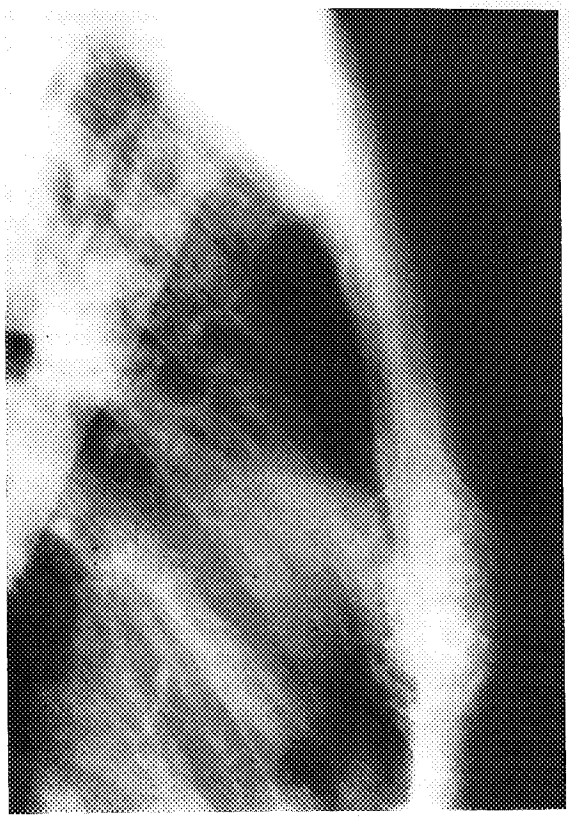


Figure 4. Chondrosarcoma of the sternum is shown in this x-ray film.

topathology of chondrosarcoma. These authors describe the features that distinguish chondrosarcoma from its benign sister tumor. More recently, Marcove and Huvos[21] developed a grading system for chondrosarcoma based on the degree of cellularity and pleomorphism. This morphologic classification was correlated with the clinical behavior of the tumor, specifically, frequency of local recurrence (grade I), slow death due to tumor (grade II), and rapid fatal progression of the tumor (grade III).

The usually slow growing but frequently painful mass may involve adjacent ribs, pleura, muscle mass, or even underlying lung. A palpable mass is usually present on physical examination, and there may be evidence of inflammation in the form of redness or increased temperature of the overlying skin. The mass is usually tender, and involvement of the muscle and possibly the subcutaneous tissue sometimes makes the skin poorly movable over the tumor. Chest roentgenography often reveals a large lobulated mass with evidence of soft tissue involvement along with bone destruction and scattered mottled calcification. Oblique views and tomographic techniques may be particularly helpful in assessing the extent of involvement of adjacent ribs, soft tissue, and visceral structures.

Radiation therapy has proved to be of little or no value in the treat-

ment of chondrosarcoma.[22, 28] Hence, early thorough surgical excision is required. Inadequate resection uniformly results in local recurrence within a year or two. The 25 to 30 per cent five-year survival statistics in this disease, despite a low rate of distant metastasis (less than 10 per cent), testify to tardy and timid surgical intervention.[12]

Myeloma

Since myeloma (plasmacytoma) is truly a systemic disease rather than a localized tumor, the fact that between 25 and 30 per cent of all primary malignant tumors in the chest wall are of this type may be a bit misleading.[30] The incidence may actually be higher than this since many cases are diagnosed by needle biopsy and are not reported as primary chest wall tumors. Myeloma, which is familiar as multiple punched-out lytic lesions in the skull, is not so readily recognized when it takes the form of a solitary similar appearing lesion in a rib or in the sternum (Fig. 5).[26] The area over the tumor may be somewhat tender, but there is usually no palpable mass present in these patients. Careful radiographic survey of not only the ribs and sternum but also the remainder of the skeletal system should be undertaken to look for additional characteristic lesions. Since myeloma is a systemic disease, generalized signs and symptoms may be present, such as fever or weakness and characteristic myeloma protein in the serum of the patient.

Should the evidence point strongly to myeloma and the tumor be readily accessible, needle biopsy may be preferable to open surgical biopsy in obtaining tissue for histologic confirmation. If the location of the tumor precludes a safe approach for needle biopsy, open surgical biopsy can usually be accomplished. Local therapy, either surgery or radiation, may

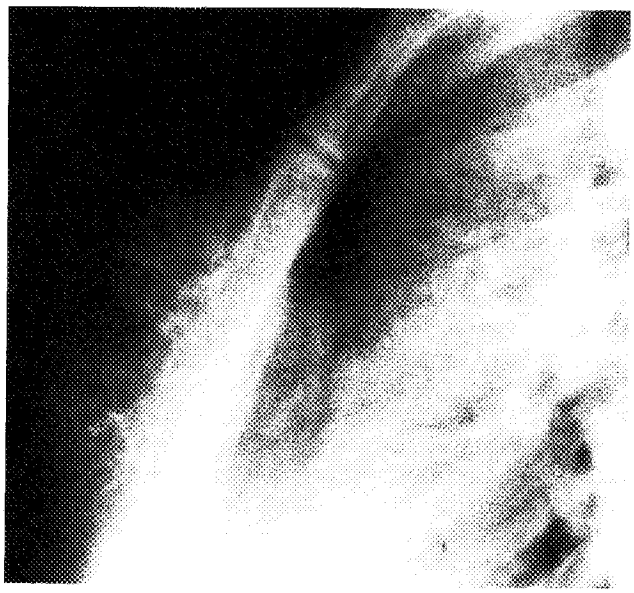
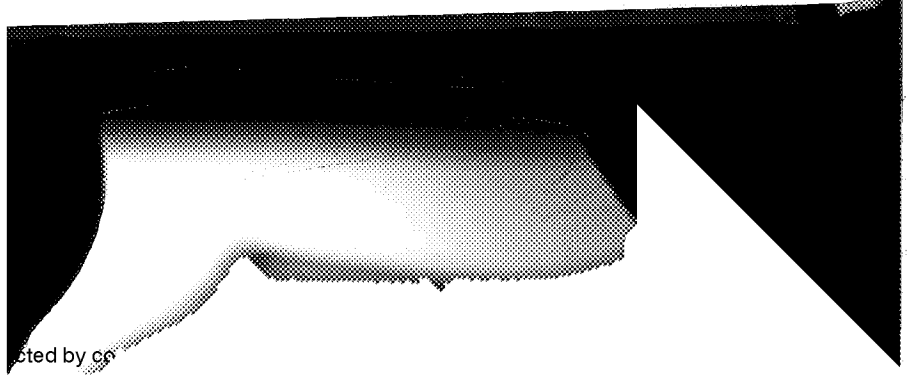


Figure 5. Myeloma (plasmacytoma) of the sternum is demonstrated in this x-ray film.



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have a role in selected cases, but systemic chemotherapy is almost always the treatment of choice.[12]

Osteogenic Sarcoma

Osteogenic sarcoma is a rapidly growing malignancy that has its peak incidence in individuals in their teens and early twenties. Rapid vascular invasion by the tumor leads to early pulmonary metastatic disease presumably from blood-borne tumor cells. The occurrence of this tumor in the chest wall is rare, but its notoriously poor prognosis when present in this location should alert the physician to think of osteogenic sarcoma whenever a chest wall tumor presents itself.

Clinically, the tumor may present as a painful, rapidly expanding mass that may originate on any of the bony structures of the chest wall. The radiographic appearance of the tumor ("sunburst-like") is said to be characteristic. Accurate evaluation for the presence of pulmonary metastases as well as assessment of the local extent of disease are prerequisites for institution of appropriate surgical therapy. Wide local surgical excision of the primary tumor is most often appropriate. When ipsilateral pulmonary metastases are present, these may be removed by wedge resection. Contralateral metastatic disease indicates the need for a staged approach. Despite radical local excision and removal of pulmonary metastases, the prognosis in primary osteogenic sarcomas of the chest wall has been particularly poor. Recent therapeutic trials with chemotherapy in the long bone version of this tumor show considerable promise for a multi-disciplinary approach to control of these tumors.[29]

Ewing's Sarcoma

Ewing's sarcoma is recognizable by the characteristic "onionskin" calcification produced by the periosteal elevation over the tumor. The disease is most common in the adolescent age group, a third of whom will exhibit distant bony metastasis at the time of discovery.[13] Ewing's sarcoma is much more common in the long bones of the body but can occur in the ribs or other structures of the bony thorax. Fever, generalized malaise, and the presence of an elevated erythrocyte sedimentation rate (ESR) may alert the astute physician to the likelihood that this tumor is present.

Open surgical biopsy is essential for accurate histologic diagnosis. Once the diagnosis has been established, therapeutic options must be considered. Because of expected poor survival, many recommend radiation therapy alone,[6, 13] whereas others, whose approach is more aggressive, recommend wide surgical resection.[25] In a recent report,[3] four patients having a "vasoformative differentiation" variant of Ewing's sarcoma were treated with a combination of surgery, radiation, and chemotherapy. The successful outcome in three of these patients gives hope for future developments in the therapy for this very aggressive tumor.

Other Tumors

Most other soft tissue sarcomas have been reported to occur with low frequency in the chest wall. These include fibrosarcoma,[31] angiosar-

coma,[23] neurosarcoma,[31] and liposarcoma.[23, 31] Sporadic cases of Hodgkin's[2] and reticulum cell sarcoma[29] arising in the sternum have been reported. Although resection is a therapeutic option in these patients, local intensive radiation therapy seems more widely applicable. The solitary form of histiocytosis, eosinophilic granuloma, may present as a painful lytic lesion in the rib with or without a surrounding soft tissue or bony mass. The fever and leukocytosis that may accompany this lesion can result in the mistaken diagnosis of osteomyelitis. Careful radiographic assessment of the entire skeletal system should be undertaken to detect other lesions. Truly localized tumors of this type can be treated by either curettage or low dose local irradiation.[12]

SURGICAL TECHNIQUES

The surgical resection of major chest wall tumors, benign or malignant, requires special preoperative planning with consideration of the overall condition of the patient, the status of the overlying skin, the anticipated skeletal defect, and the available options with respect to reconstruction and support. Historically, it is interesting to recall that in 1921 Hedblom wrote that the "prevention of pneumothorax and combating its immediate harmful effects have been the chief considerations in operating on chest wall tumors."[13] Early work at the Lahey Clinic,[33] however, included reports of successful resections with no attempts made to reconstruct a stable chest wall. The group from Memorial Hospital in 1969 nicely summarized the modern approach to systematic preparation for resections involving major skeletal or integumentary loss, or both.[22]

It should be pointed out that radical surgical excision is just what its name implies, and no compromise should be made to reduce the size of the defect. Full thickness resection of the chest wall is advised for all sarcomas. This should be combined with early entry into the pleural space to a distance of at least one normal interspace beyond the tumor to assess the extent of intrathoracic involvement.[20] The apparent encapsulation of many of the cartilaginous tumors will tempt one to "shell out" the tumor, leaving behind islands of viable tumor cells.[27] Previous biopsy sites should be included in the resection of all malignant tumors. Direct involvement of the skin or damage of the integument by prior radiation therapy may also increase the amount of skin that must be sacrificed.

The location of the tumor is also important in the plan for resection. For example, a sternal tumor may be confined to either the body or the manubrium, thereby allowing preservation of the uninvolved end of the sternum for midline stability. In the report from Martini and associates in 1974,[23] this was accomplished in 13 of 14 sternal resections, and no respiratory assistance was required in this group. Large skeletal defects (three to four ribs) in the posterior chest wall may require no stabilization or repair at all because of the support afforded by the scapula.[19] On the other hand, extensive reconstruction from available tissue or prosthetic material may be required when the defect is anterior.[1, 5]

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store chest wall stability when stabilization is necessary to prevent paradox or to protect the underlying organs. The most commonly used at this time seems to be Marlex mesh. This slightly stretchable, extremely strong woven polymer meets nearly all the criteria for the ideal prosthesis.[19] It is virtually inert, flexible, easily cut and handled, translucent by x-ray, easily fixed, readily incorporated into tissues, and well tolerated, sometimes even in the presence of infection.[12] When stretched taut it is quite rigid, although in certain areas, such as the chest that has undergone total sternectomy or massive lateral chest wall resections, rigidity and shape can perhaps be better maintained by construction of a "sandwich" of Marlex with two layers of the mesh over a filler of acrylic resin (methyl methacrylate). Such a composite prosthesis can be custom prepared at the time of surgery with minimal difficulty and delay.[1, 4] *A potential pitfall that might occur with the use of prosthetic material, however, is failure to appreciate the effect of the patient's position on the chest wall prosthesis.* A difference of as much as 5 cm in the distance between the third and seventh ribs has been found when the patient is taken from the lateral position and allowed to assume a normal erect posture with the arms at the sides. This can be corrected, or at least allowed for, by placing the prosthesis in with considerable tension and altering the patient's position by flexing the upper portion of the operating table or having the anesthesiologist push the shoulder girdle inferiorly.[9]

Primary closure of the skin should be possible in the majority of chest wall resections.[4, 22] However, where there is skin involvement with tumor or skin damage from prior surgery or irradiation, the surgeon must be prepared to reconstruct an air-tight integumentary cover for the chest wall. A host of local flaps are potentially available for this purpose, including breast, deltopectoral cutaneous, and thoracoabdominal cutaneous flaps.[34] Myocutaneous flaps of latissimus dorsi muscle may provide additional substance for deep defects. The omentum has also been used for chest wall reconstructions in which there has been extensive skin loss.[7, 10, 32] In these instances split thickness skin grafts may be used to provide the final layer in a one stage repair.

Respiratory insufficiency following major chest wall resection is not nearly as common as one might think.[17] Baue's total sternectomy, for example, required no respiratory support at all.[5] In some centers, however, ventilatory support for major chest wall resections has been routinely employed for up to five to six days postoperatively.[20] Obviously, a great deal of individual consideration should be given, with support available but not necessarily committed. If ventilatory support is not required, early ambulation of these patients may prevent some of the untoward effects of prolonged immobilization. Since individual experience with chest wall resections has been limited, the complications of these operations have been poorly documented. Nearly half of the patients, however, do develop some pulmonary problems, most frequently atelectasis, and local wound complications (usually seromas) are also quite common.[4] Most of these difficulties, however, can be effectively treated if recognized early.

SUMMARY

Primary tumors of the chest wall are uncommon but should be considered in the evaluation of patients with persistent chest wall pain or the presence of a chest wall mass, especially when this is near the costal cartilages. Special radiographic techniques may help to define the diagnostic possibilities and the extent of local involvement. Since at least half of the primary rib tumors and virtually all of the sternal tumors are malignant, these problems demand prompt investigation, accurate tissue diagnosis, and, usually, generous surgical excision.

With appropriate attention to skin, soft tissue, and skeletal involvement, resection of major chest wall tumors can be done safely, and there are a variety of reconstructive techniques available to deal with the resulting defects. Radiotherapy has little role in the treatment of chest wall tumors except for the myeloproliferative disorders and possibly some cases of Ewing's sarcoma. Chemotherapy has similarly been ineffective for the cartilaginous tumors but shows some promise in the multidisciplinary approach to osteogenic sarcoma. Surgical resection, however, remains the mainstay for the treatment of most tumors of the chest wall. Even in instances of recurrent disease there are many whose long-term survival has been achieved by multiple operative procedures.

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REFERENCES

1. Alonso-Lej, F., and DeLinera, F.: Resection of the entire sternum and replacement with acrylic resin. Report of a case of giant chondromyxoid fibroma. J. Thorac. Cardiovasc. Surg., 62:271, 1971.
2. Arnold, H., Meese, E., D'Amato, N., et al.: Localized Hodgkins' disease presenting as a sternal tumor and treated by total sternectomy. Ann. Thorac. Surg., 2:87, 1966.
3. Barnard, R., Martini, N., and Beattie, E.: The value of resection in tumors involving the chest wall. J. Thorac. Cardiovasc. Surg., 68:530, 1974.
4. Barson, A., Ahmed, A., Gibson, A., et al.: Chest wall sarcoma of childhood with a good prognosis. Arch. Dis. Child., 53:882, 1978.
5. Baue, A.: Total resection of the sternum. J. Thorac. Cardiovasc. Surg., 45:559, 1963.
6. Blades, B., and Paul, J.: Chest wall tumors. Am. Surg., *131*:976, 1950.
7. Carberry, D., and Ballantyne, L.: Omental pedicle graft for chest wall revascularization and reconstruction. Exhibit, Clinical Congress American College of Surgeons, San Francisco, 1975.
8. Dashiell, T., Payne, W., Hepper, N., et al.: Desmoid tumors of the chest wall. Chest, 74:157, 1978.
9. Dineen, J., and Boltaxe, R.: Problems in the management of chest wall tumors. J. Thorac. Cardiovasc. Surg., 52:588, 1966.
10. DuPont, C., and Menard, Y.: Transposition of the greater omentum for reconstruction of the chest wall. Plast. Reconstr. Surg., 49:263, 1972.
11. Graham, J., Usher, F., Perry, J., et al.: Marlex mesh as a prosthesis in the repair of thoracic wall defects. Ann. Surg., *151*:469, 1960.
12. Groff, D., and Adkins, P.: Chest wall tumors. Ann. Thorac. Surg., 4:260, 1967.
13. Hedblom, C.: Tumors of the bony chest wall. Arch. Surg., 3:56, 1921.

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Thorac. Cardiovasc. Surg., 45:559, 1963.
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: Desmoid tumors of the chest wall. Chest,

the management of chest wall tumors. J.

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263, 1972.
arlex mesh as a prosthesis in the repair of
9, 1960.
rs. Ann. Thorac. Surg., 4:260, 1967.
ll. Arch. Surg., 3:56, 1921.

14. Hedblom, C.: Tumors of the bony chest wall, study of 22 personal cases. Ann. Surg., *98*:528, 1933.
15. Hochberg, L., and Rivkin, L.: Benign neurogenic tumors of the chest wall. Ann. Surg., *138*:104, 1953.
16. Hubbard, S., Todd, E., Carter, W., et al.: Repair of chest wall defects with prosthetic material. Ann. Thorac. Surg., 27:440, 1979.
17. Jaffe, H., and Lichtenstein, L.: Chondrosarcoma of bone. Am. J. Pathol., *19*:553, 1943.
18. Kreel, L.: Computed tomography of the thorax. Radiol. Clin. North Am., *16*:575, 1978.
19. LeRoux, B.: Maintenance of chest wall stability. Thorax, *19*:397, 1964.
20. Lopez, R., Didolkar, M., Karakousis, C., et al.: Problems in resection of chest wall sarcomas. Am. Surg., 45:471, 1979.
21. Marcove, R., and Huvos, A.: Cartilaginous tumors of the ribs. Cancer, 27:794, 1971.
22. Martini, N., Starzynski, T., and Beattie, E.: Problems in chest wall resection. SURG. CLIN. NORTH AM., *49*:313, 1969.
23. Martini, N., Huvos, A., Smith, J., et al.: Primary malignant tumors of the sternum. Surg. Gynecol. Obstet., *138*:391, 1974.
24. Ochsner, A., Lucas, G., and Mc Farland, G.: Tumors of the thoracic skeleton. J. Thorac. Cardiovasc. Surg., 52:311, 1966.
25. Omell, G., Anderson, L., and Bramson, R.: Chest wall tumors. Radiol. Clin. North Am., *11*:197, 1973.
26. O'Neal, L., and Ackerman, L.: Cartilaginous tumors of ribs and sternum. J. Thorac. Surg., *21*:71, 1951.
27. Pandey, S.: Giant chondromas arising from the ribs. J. Bone Joint Surg. (Br.), 57:519, 1975.
28. Pascuzzi, C., Dahlin, D., and Clagett, O.: Primary tumors of the ribs and sternum. Surg. Gynecol. Obstet., *104*:390, 1957.
29. Rosen, G., Marcove, R., Caparros, B., et al.: Primary osteogenic sarcoma. The rationale for preoperative chemotherapy and delayed surgery. Cancer, 43:2163, 1979.
30. Teitelbaum, S.: Twenty years experience with intrinsic tumors of the bony thorax at a large institution. J. Thorac. Cardiovasc. Surg., 63:776, 1972.
31. Threlkel, J., and Adkins, R.: Primary chest wall tumors. Ann. Thorac. Surg., *11*:450, 1971.
32. Vetto, M., Rubin, S., and Bernards, W.: Closure of large thoracic wall defects using an omental particle. Am. Surg., 43:724, 1977.
33. Watkins, E., and Gerard, F.: Malignant tumors involving the chest wall. J. Thorac. Cardiovasc. Surg., 39:117, 1960.
34. Wojtanowski, M., and Mandel, M.: Osteoradionecrosis of the thoracic wall and its surgical management. Am. J. Surg. *138*:434, 1979.

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